

quite regularly rather than incidentally (occurring at least in 1965, 1966, and 1969).

Consequently, it is concluded that the presence of anchovies in northern waters does not represent a mere expansion of this species' geographic range—an expansion that well might have accompanied its recent fivefold increase in total population size. The previously mentioned genetic and meristic evidence, the results of recent larvae surveys, and the above length-frequency analysis would all seem to refute such a conclusion. Moreover, since this subpopulation was the mainstay of a substantive fishery for live bait during the 1940's (Pruter 1966), it seems to have been a persistent feature of the Washington-Oregon coast even before the dramatic expansion of the anchovy biomass which followed the demise of the sardine. Thus the weight of evidence seems to indicate that the northern subpopulation of anchovies is one of three independent population elements, all of which are capable of spawning and producing their own recruitment.

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COMMENT. INTRODUCTION OF *CODIUM* IN NEW ENGLAND WATERS

Genus *Codium* is one of the most common forms of seaweed found in almost every latitude but, until recently, has been absent from the east coast of North America. *Codium* attaches to rocks, pilings, old molluscan shells, and also shells of living oysters, scallops, and mussels. This algae has a number of common names, such as spaghetti grass, staghorn, deadman's fingers, and Japanese weed. It grows rapidly and often becomes so dense that it sometimes creates undesirable conditions on cultivated and natural shellfish beds, as well as in some other environments. At times it becomes buoyant enough to float and to carry along with it mollusks, to the shells of which it is attached. Mass mortalities of *Codium* are usually followed by quick decomposition, creating adverse conditions that result in the death of mollusks and other bottom forms.

No *Codium* was known to exist in New England waters until approximately the end of the 1950's, when the first specimens of *Codium fragile* were reported from several aquatic areas adjacent to Long Island. Since then it has become established in the waters of New England, spreading as far north as the State of Maine. According to a recent article (Quinn 1971) "It is now a dominant seaweed in the waters of Eastern Long Island and

can be found from Barnegat Bay, N.J., to Boothbay Harbor, Me.”

Because of its wide distribution in the new environment, *Codium* now causes serious impact on local ecology and also creates serious problems on shellfish beds. There is some question, naturally, as to when the first introduction of this algae occurred and how this somewhat undesirable “immigrant” was brought into our eastern waters. Quinn (1971) quotes Mueller, who, apparently without any evidence, speculates that “It was imported on the backs of oysters from Europe and Japan.” Since I am responsible for the introduction of the European oyster, *Ostrea edulis*, into the waters of New England (Loosanoff 1951, 1955), I wish to comment on this matter.

The European oysters were brought to Long Island Sound in October 1949, when I was the Director of the United States Bureau of Commercial Fisheries Biological Laboratory at Milford, Conn. The shipment was comprised of approximately 2 bushels of the mollusks, ranging in age from 1 to 3 yr. They were shipped in a vegetable compartment of a large refrigerator on a Holland-American Line passenger ship and spent about 13 days in transit.

The introduction of *O. edulis* was made in accordance with the decision reached after my consultations with members of the shellfish industry, as well as with leading marine biologists of that period, including Paul S. Galtsoff of the United States Bureau of Commercial Fisheries and Thurlow Nelson of Rutgers University. Federal authorities approved the importation and the Director of the State of Maine Sea and Shore Fisheries, who was extremely interested in planting European oysters into those waters, gave me a small sum of money to pay for that shipment. The latter fact, obviously, discredits Mueller’s statement, quoted by Quinn, that “The oysters were removed from Milford and Woods Hole without permission and introduced into local waters.”

In introducing European oysters it was our desire to establish a second commercial species of bivalves in the waters of Maine. At that time only one mollusk, the soft-shell clam, *Mya arenaria*, was commercially utilized in that region. However, because of extremely heavy mortality among the *Mya* in the mid-1940’s, this species became almost extinct for a period of

several years. As a result, many shore communities which depended upon soft-shell clam fisheries were deprived of the chief means of their livelihood. Therefore, it seemed logical to me that a second shellfishery should be developed in those waters, namely that of *O. edulis*. If successful such a development would enhance the economy of the region. *Ostrea edulis* was chosen for the cold waters of Maine because, in addition to its high quality as human food, it is able to propagate at a considerably lower temperature than the American oyster, *Crassostrea virginica*.

In bringing the oysters from Europe, I dealt with my friend, Peter Korrिंगa, who is now Director of the Netherlands Institute for Fishery Investigations. At that time he was already considered one of the world’s leading shellfish experts. Being fully aware of the possibility of introducing undesirable exotic species which might accompany the European oyster, our group of American biologists, as well as Korrिंगa, decided to take precautionary measures considered sufficient to prevent such an occurrence. The problem was discussed at great length in correspondence between Korrिंगa and myself, and I still have in my files several of Korrिंगa’s letters attesting to this exchange. For example, in his letter of March 1949, Korrिंगa wrote “I can kill any germs in the shell by disinfecting the consignment before shipment.” In May of the same year he wrote again “I will disinfect very carefully every oyster we ship you with the chemicals we find satisfactory to that end.” In his recent letter to me, dated 27 November 1973, Korrिंगa wrote as follows: “I suggested to treat the oysters by bathing them in a mercury solution, using the organic fungicide we used on large scale against infection with shell disease. This kills hundred percent all organisms on the outside of the shell which cannot withdraw in a hermetically closed shell. You see from my correspondence that I have treated the oysters with this disinfectant before shipping them. Therefore I feel sure that *Codium fragile* cannot have been introduced in the American Atlantic waters with our oysters.”

When the oysters arrived at Milford, they were again carefully examined, washed with fresh water, and dipped in a weak solution of copper salt. At that time, however, we were not concerned as much with the introduction of *Codium*

as we were afraid of bringing along a highly destructive fungus causing so-called "oyster shell-disease." Because of Korringa's assurance, however, we were quite certain we would eliminate this and any similar dangers.

The small shipment of European oysters was later divided into two parts, one taken to the U.S. Bureau of Commercial Fisheries Laboratory at Boothbay Harbor, Maine, where some of the oysters were suspended off the dock, the other part kept in Milford Harbor, remaining there under the observation of my associates and me for several years. Not in a single instance did I, other members of Milford Laboratory, or John B. Glude, Director of the U.S. Bureau of Commercial Fisheries Laboratory at Boothbay Harbor, or his colleagues, notice or report to me the presence of *Codium* on the oyster shells. Therefore, considering the chemical treatment that was given the oysters before they were placed in open American waters and because of the results of our long-term observations of these oysters at both Milford and Boothbay Harbor, it is improbable that *Codium* was brought into the waters of New England "on the backs of the European oysters."

There are several much more plausible explanations as to the way *Codium* was introduced to our Atlantic coast. In my opinion, it was brought into our waters during World War II. At that time, to avoid being torpedoed by German submarines along the open Long Island coast, many freighters coming from Europe to the port of New York traveled through the well-protected inside passage—Long Island Sound. At times, these vessels were so numerous that many of them had to be anchored in Long Island Sound for several weeks before they could be unloaded at New York piers. I was then engaged in the study of plankton of Long Island Sound—in relation to propagation of oysters—running, sometimes, 14-h sampling series from a small boat. Several of our collecting stations were then located on the Bridgeport and New Haven oyster beds where seed oysters were dredged each fall and planted on cultivated beds of Long Island, Rhode Island, Massachusetts, and even Maine (Loosanoff 1966).

To avoid the wind and heavy wave action we would usually position our boat on the lee side of anchored freighters. Often we were so close to those vessels that we could converse with

members of their crews. Many of these ships were of European registry and, because of the war, most of them were not able to undergo proper bottom cleaning for several years. As a result of this neglect, the ship bottoms were covered with heavy layers of marine fouling organisms. Sometimes such layers, as had been reported by Woods Hole investigators, were as much as 2, or even 3, feet thick (Woods Hole Oceanographic Institution 1952). The fouling mass was composed of many forms, including mussels, tunicates, and, no doubt, a variety of other organisms. The *Codium* was also present and sometimes clearly visible. While the freighters were riding at anchor, frequently large chunks of the fouling mass broke off and fell to the bottom of the Sound. We witnessed this phenomenon on numerous occasions.

Thus, it appears logical that *C. fragile* gained entrance into the waters of eastern United States from the bottoms of European freighters during World War II. This possibility, however, seems to be ignored; the blame is placed instead, directly or indirectly, on a small, properly handled shipment of European oysters which was brought from Holland to Milford in 1949 (Quinn 1971).

It may be mentioned, in conclusion, that, as originally planned, the European oysters planted in Boothbay Harbor not only survived in the new environment but reproduced under a new set of ecological conditions and became firmly established within a large area (Welch 1966). Therefore, these excellent "immigrants" may soon become the second commercial shellfish crop of Maine. Secondly, *Codium*, although a nuisance and a highly undesirable invader in some respects, and for introduction of which we claim no "credit," may be a welcome addition to localized biosystems by providing extensive, rich-in-food, protective nursery areas to the advanced larval stage and juveniles of many fishes and of such important species of commercial invertebrates as the American lobster, *Homarus americanus*, and the blue crab, *Callinectes sapidus*.

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